14.310x Flipped Classroom materials

rduranl

Course Guide

14.310x Flipped Classroom
Week 1 Instructions

Some title

Checklist

- ☐ Complete the INTRO TO R interactive course from the `Swirl` package[1] (Requirement)
- ☐ Watch the Getting started with Google Colab notebooks video tutorial (Requirement)
- ☐ Create or set up a personal Google account
  (you must be able to use Drive and Colab). (Requirement)
- ☐ Create your first Colab notebook (Session 1)
- ☐ Complete Coding Lab 1. (Session 1)
- ☐ Complete Coding Lab 2 (Session 2)

C.1.0

Your first Colab notebook

Instructions: Read and follow the steps below **before proceeding with the activity**. After reading the instructions, access the notebook link and complete the exercises in Colab. This is an individual task, but you will collaborate on the final question.

Notebook: Your first Colab notebook

[1]**Module 1 > Introduction to R** in the online component of the course.

We will cover the essentials of working with Jupyter Notebooks on Google Colab — this resource will be an important tool throughout. Before you can begin working on the coding labs in Colab, make sure to:

- **Create or use a personal Google account**. While it is possible for you to download the Jupyter Notebooks we will work on, and manage them locally in your own machine, we strongly advise you to work on Colab since it will make it easier for your classmates and the instructor to interact with your work when needed. Colab has many features Google Drive already offers: comments, real-time colaboration in the same document or folder, etc.
- **Save the shared notebooks and documents to your own drive.** The notebooks you will have access to are read-only; in order to work on them you will have to copy them to your drive. It is recommended that you maintain a per-week structure in your folders as this will make it easier to follow instructions, especially when reading files or collaborating with others. To save the notebook to your Drive, go to the File menu: `File > Save a copy in Drive`.
- **(When creating a new notebook) Change Colab Notebook's runtime type to R.** By default, when you create a new notebook in Colab, the virtual machine Colab sets up for you is a `Python` installation. This means all the cells in the notebook will only recognize and run `Python` syntax or commands. To switch to an `R` language setup:
  1. Open the notebook menu and go to `Runtime > Change runtime type`.
     - Or click the toggle in the upper-right corner (as shown below) and select `Change runtime type`
  2. In the dropdown labeled `Runtime type`, select `R`.
  3. Click `Save`.

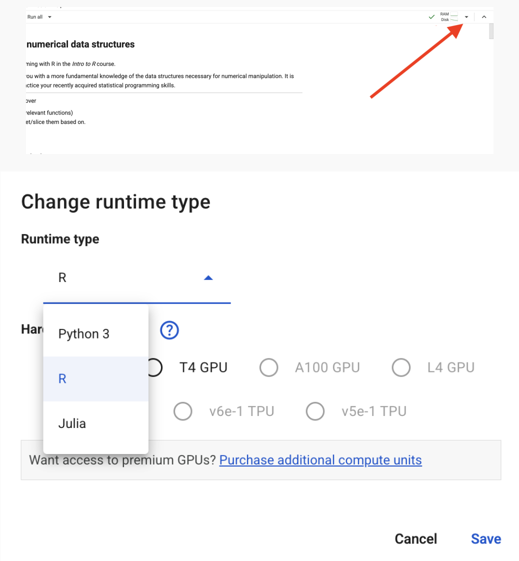

Fig. Changing the runtime type

You may now create your first Colab notebook

C.1.1

Coding Lab 1— Numeric data structures in R

Instructions: Work individually. Solve all exercises in the corresponding Colab notebook. Record your answers and/or code in your copy of the notebook.

Notebook: Coding Lab 1

Submit your work in the format required by the instructor.

C.1.2

Coding Lab 2 — Data manipulation with `dplyr`

Instructions: Work individually. Solve all exercises (sections 0 to 3) in the corresponding Colab notebook; record your answers and/or code in your own copy.

Notebook: Coding Lab 2

Optional **Section 4** allows work in pairs or teams of 3.

Upon completion, submit your work in the format required by the instructor.

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Week 2 Instructions

Some title

Checklist

- ☐ Complete the ADVANCED R interactive course from the `Swirl` package and watch the `ggplot` tutorial[2] (Requirement)
- ☐ Watch the **Import Data** tutorial[3] (Requirement)
- ☐ Read the note on importing `aiwars` and other datasets (Requirement)
- ☐ Complete Coding Lab 3 (Session 1)
- ☐ Complete Guided Case 1 (Session 2)

Importing `aiwars` and other datasets

Depending on flipped classroom logistics of your group, your access to the sessions' assets (datasets, figures, scripts, etc.) will come in one of two forms:

- **Through a direct URL** for instance, the original `aiwars.csv` dataset lives directly in this URL:
  `https://docs.google.com/spreadsheets/d/1NeZZWI2fT71M9QD8zjnz817T1B3XBM6lolqArSe9CwQ/export?format=csv`
- **Your instructor will provide them to you privately** and they will either:
  - Share them via a URL similar to the one above.
  - Share the files through other means.

[2] **Module 2 > R Course and R Tutorial: ggplot** in the online component of the course.
[3] **Module 3 > R Tutorials: Basic Functions** in the online component of the course.

As they may want to slightly modify the original files for grading purposes, or have any other goal in mind.

If a dataset's URL is provided, you can read the data directly into R with the URL and the appropriate reading function; simply provide the URL as the path. For instance, `aiwars` is in `.csv` format:

```
URL_aiwars <- "https://docs.google.com/spreadsheets/d...."

aiwars <- read.csv(URL_aiwars)
```

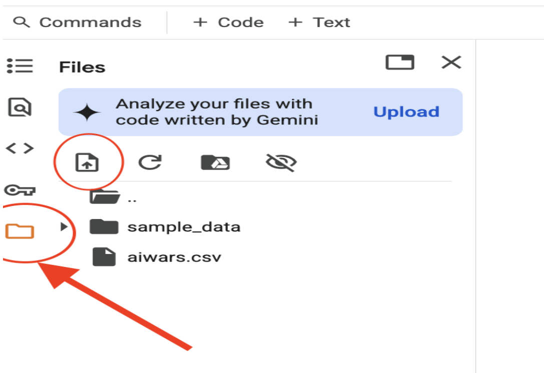
And similarly for other formats. Suppose we had a single Excel sheet:

```
install.packages("readxl")
library(readxl)

URL_aiwars_xl <- "https://...some-URL"

aiwars <- read_excel(URL_aiwars_xl)
```

If the file is shared in any other way, we will first need to upload it to the virtual machine's disk in Colab and read it from there, providing the `path` to it — as you would do if you were reading data to R in your own computer. To upload a file in Colab, click the folder icon in the leftmost menu bar, as shown in the screenshot. Then click the upload icon (circled in red); as you can see, we already uploaded the file.



Once uploaded the file can be read as a if in your machine:

```
aiwars <- read.csv("aiwars.csv")
```

Important: Colab runtime limitations

While your Colab notebook — including all code cells, text, and outputs — will remain saved, the underlying *runtime* (i.e., the virtual machine that executes your code) is temporary. After a period of inactivity or when a time limit is reached, the runtime will automatically disconnect.

When this happens:

  - All variables and objects stored in memory (e.g., your R data frames, models, vectors) will be lost.
  - Any files you uploaded manually will be erased.

When reconnecting, a fresh virtual machine will be started, and you'll have to re-run your code, and re-upload any needed files. Disconnects may happen occasionally as you work in off-notebook tasks; re-reading or re-uploading files should not take over 30 seconds.

C.2.3

Coding Lab 1 — Web Scraping in R: step by step guide

Instructions: Work individually. Solve all exercises in the corresponding Colab notebook. Record your answers and/or code in your copy of the notebook, or in the format required by the instructor.

Notebook: Coding Lab 1

---

1. ((* prompt("A@Q2.1") *))
2. non-code exercise
3. ((* prompt("A@Q2.2) *))

Case study G.2.1

Random variables in the wild: *Reddit* posts and empirical distributions

Instructions: Work in pairs or groups of three. Answer the questions

Notebook: Guided Case 1

using a real-world dataset from Reddit. You will practice empirical techniques for distributions representation, examine relationships between random variables, and interpret your results based on plots and numerical calculations.

Context: The `AIwars` dataset consists of a collection of posts scraped from the `r/AIwars` subreddit, a forum where users debate the societal implications of AI. These range from predictions about AI-driven job loss and technological conflict to satire, trolling, and speculation. The dataset captures a rich period of discussion and polarization. Each observation corresponds to a single post, with information about its author, contents and engagement.

Key Variables:

- `post_index` — Unique identifier for each post (starts at 1 and consecutively numerates all posts).
- `author` — Reddit username of the post author (may be `[deleted]`).
- `post_date` — an R `Date`
- `fulltext` — Full text of the Reddit post in format `"TITLE: [some post title] TEXT: [some post text]"`
- `post_length` — the net number of characters in `fulltext` (excludes the TITLE: and TEXT: headers).
- `post_upvotes` — Number of upvotes (user endorsements or "likes") the post received.
- `num_comments` — Total comments the post received (includes replies to other comments).

Scenario:

1. ((* prompt("B@Q2.3") *))
2. non-code exercise
3. ((* prompt("B@Q2.4) *))

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Week 3 Instructions

Some title

Checklist

- ☐ Complete Guided Case Study 2 (Sessions 1 & 2)
  - ☐ We will continue to work with `aiwars`
  - ☐ Get the `aiwars_embeddings` dataset here
- ☐ Complete Open Case Study 1 (Session 2)

Case study G.3.2

Analyzing text similarity: language semantics as random variables

Instructions: Work on your own for Session 1, and in pairs or groups of 3 for Session 2.

Scenario: We will motivate continuous random variables, as well as marginal and conditional distributions, through an applied example using *semantic embeddings* of the Reddit posts you previously worked with in the `aiwars` dataset.

Natural Language Processing (NLP) focuses on enabling machines to understand and work with human language. One of the key advances in NLP has been the development of methods that represent text — such as words, sentences, or entire posts — as mathematical vectors (yes, the vectors in $\mathbb{R}^n$ just like the ones you know from calculus). These vector representations, often referred to as *embeddings*, capture aspects of a text's semantic content: its meaning, tone, and topical focus.

Embedding the `aiwars` posts

As explained above, an **embedding** is a way to represent a piece of text (like a Reddit post) as a numeric vector of length n. For instance, you will be able to verify that post 947[4]:

```
> aiwarsfulltext[947]
[1]"TITLE: Protect the artists TEXT: Datasets needs to be destroyed."
```

Is represented by the the same row in `embeddings[947, ]`

```
[1]  9.470000e+02, -1.289627e-02, -4.513694e-02, ... , -0.008391287
```

Formed by variables $v_1, v_2, ..., v_{3072}$. And similarly for every post.

vector $V \in \mathbb{R}^n$ could represent

$$V = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \\ \vdots \\ v_n \end{pmatrix} \tag{1}$$

What length will this vector have?

These numbers come from a model that captures the post's *meaning*. Posts with similar ideas will have similar embeddings. We won't worry about how they are built — just know they work like a *meaning fingerprint*.

What is Cosine Similarity?

Cosine similarity measures **how similar the direction** of two vectors is.
- If two vectors point in the same direction: similarity = 1.
- If they are perpendicular: similarity = 0.
- If they point in opposite directions: similarity = -1.

Cosine similarity ignores the *length* of the vector — so it's perfect for comparing text, which can vary in length and word choice.

Why Use Cosine Similarity?

- **Captures meaning similarity** regardless of specific words used.
- **Insensitivity to length** (e.g. short vs long posts).
- **Simple to compute** once you have vectors.

Examples

- Post A and Post B both discuss AI bias $\Rightarrow$ Cosine similarity ≈ 0.98.
- Post A and Post C talk about completely different topics $\Rightarrow$ Cosine similarity ≈ 0.05.

Exercises

Exercise 1: Manual Computation (2D Example)

Given two vectors:

```
a <- c(1, 2)
b <- c(2, 4)
```

Compute cosine similarity step-by-step in R:

```
dot_product <- a[1]*b[1] + a[2]*b[2]
norm_a <- sqrt(a[1]^2 + a[2]^2)
norm_b <- sqrt(b[1]^2 + b[2]^2)
cos_sim <- dot_product / (norm_a * norm_b)
```

Exercise 2: Define Your Own Function with a Loop

Create a cosine similarity function using a loop:

```
cosine_similarity_loop <- function(a, b) {
dot <- 0
norm_a <- 0
norm_b <- 0
for (i in seq_along(a)) {
dot <- dot + a[i] * b[i]
norm_a <- norm_a + a[i]^2
norm_b <- norm_b + b[i]^2
}
return(dot / (sqrt(norm_a) * sqrt(norm_b)))
}
```

Exercise 3: Apply to a Dataset

Suppose you have a matrix `X` where each row is an embedding. Compute cosine similarity between a reference post and all others:

```
reference <- X[42, ]  # embedding of the reference post
sims <- apply(X, 1, function(row) cosine_similarity_loop(row, reference))
```

---

[4] https://www.reddit.com/r/aiwars/comments/13kos2f/protect_the_artists

Case study O. 3. 1

Instructions: Work in pairs or groups of three. Share a Colab Notebook where you previously load `cos_post1`, `cost_post2` and the `aiwars`. Create a deck with a minimum of 10 and a maximum of 15 slides, and a minimum of 4 summarizing plots to answer the following questions:

Scenario: We previously examined the cosine similarity of AIWars to two "gold standard" posts (a and b) in isolation — thinking of these similarities as continuous random variables that capture how close in meaning a given post is to each extreme.

In this case study, you'll explore how these semantic similarities relate to the the rest of variables we examined for `aiwars` : post length, popularity and activity. You will use the summarizing tools and the concepts of conditional, cumulative and marginal probability covered in the lecture to give graphical, general answers to questions on these relationships.

What can we learn abo when we condition on a post's length or number of comments?

Questions

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Week 4 Instructions

Some title

Checklist

- ☐ Complete Coding Lab 4 (Sessions 1 & 2).
- ☐ (Optional) Explore the **Review Notes** and further **Readings** available.

Coding lab L.4.4

Understanding Probability and Statistics in R: A Step-by-Step Guide

Instructions: Work individually. Answer all questions in sections 1-6. Sections 7 and 8 are optional; follow your instructor's directions.

Notebook: Coding Lab 4

Record your answers in your copy of the notebook, or in the format required by your instructor.

Additional resources

– **Drive: Review Notes**

- **Drive:** Readings

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Week 6 Instructions

Some title

Checklist

- ☐ Complete Coding Lab 5 (Session 1)
- ☐ Complete Guided Case Study 3 (Session 2)
  - ☐ Get dataset `exp1.dta`
  - ☐ Paper: (Currie et al., 2014)
- ☐ (Optional) **Review Notes** and further **Readings** available.

Coding Lab L.6.5

Understanding Confidence Intervals
Hypothesis Testing and Two Type Errors in R

Instructions: Work individually. Solve all exercises in the corresponding Colab notebook. Record your answers and/or code in your copy of the notebook.

Notebook: Coding Lab 5

Submit your work in the format required by the instructor.

Guided case study G.6.3

Replicating (Currie et al., 2014): confidence intervals and hypothesis testing with real-world data

Instructions: Work in pairs or groups of three. Read the scenario below for context on (Currie et al., 2014). Then import dataset `exp1.dta` to the designated Colab Notebook below and answer the questions therein.

Notebook: Case Study 3

Dataset: exp1.dta

Paper: (Currie et al., 2014)

The team or pair may work on one notebook collaboratively. One team member needs to share editor access their the Colab Notebook with the rest.

Scenario: Paper *Addressing antibiotic abuse in China: An experimental audit study* by Currie, Lin, and Meng (2014), examines why physicians in Chinese hospitals overprescribe antibiotics — a major public health concern linked to drug resistance.

The authors trained student actors to visit hospitals with standardized, mild flu-like symptoms and used four different "scripts" to test whether financial incentives or perceived patient demand drive prescribing behavior.

In this case study, we will use data from the first experiment (provided in `exp1.dta`) to replicate parts of the authors' analysis.

You'll estimate confidence intervals and test hypotheses about antibiotic prescription rates and physician behavior under different scenarios.

Do financial incentives significantly increase antibiotic prescriptions?
Are doctors responsive to explicit patient demand?
What can we infer with confidence about prescription patterns across conditions?

A glossary for `exp1.dta` is provided in the Notebook.

Additional resources

- Drive: Review Notes
- Drive: Readings

Bibliography

Currie, J., Lin, W., & Meng, J. (2014). Addressing antibiotic abuse in china: An experimental audit study [Land and Property Rights]. *Journal of Development Economics*, *110*, 39–51. https://doi.org/https://doi.org/10.1016/j.jdeveco.2014.05.006

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Week 7 Instructions

Some title

Checklist

- ☐ Set aside this Wikipedia article on testing two-proportions hypotheses, in case you need it during Session 2 (Requirement)
- ☐ Skim this Wikipedia article discussing the Local Average Treatment effect (LATE) , in advance of Session 2. (Requirement)
- ☐ Complete Guided Case Study 4 invidually (Session 1)
  - ☐ Retrieve the `students` dataset here
- ☐ Complete Open Case Study 2 in pairs or teams of 3. (Session 2)
  - ☐ You will continue to use `students`

Case study G.7.4

Evaluating AI-assisted learning on student outcomes

Instructions: Work on your own; read the scenario and answer the questions. Type your answers in the format required by the instructor.

To work on the `students` dataset you may use either a Colab notebook or your own installation of R.

Dataset: students.csv

Your code will not be evaluated, but keep your R script or notebook tidy, as you may need to review some of your answers during Session 2.

Scenario:

You are the Government of *Novaria*'s new Minister of Education. The Prime Minister has tasked you with evaluating a primary education policy recommendation: the rollout of AI-assisted learning for mathematics curricula in grades 5-8.

The proposed program, *Project Mentor*, involves deploying a large language model (similar to ChatGPT) named *AlgebrAI* specifically trained and fine-tuned for elementary math tutoring. AlgebrAI's interface is tailored to deliver interactive, one-on-one tutoring sessions to students. The AI mentor adapts to each student's skill level and provides problem-solving guidance, hints, and feedback designed to help the students master their grade's math curriculum.

Each participating school receives a number of tablets with AlgebrAI pre-installed, configured for offline-first use and automatically synced with central servers when internet is available. Students selected for treatment attend 20-minute tutoring sessions per day under the supervision of a facilitator.

The Prime Minister believes Project Mentor can boost test scores nationwide, but political opponents have raised concerns over cost and long-term efficacy. You are now in charge of evaluating the impact of the program in grades. Your team provides you with:

1. A 6th-grade math test designed to perfectly measure domain of the curriculum in a scale from 0 to 100.
2. A list of 1,000 students enrolled in 6th grade across Novaria, picked at random — part of the `students` dataset. This list contains only the following variables:
   - `unit`: a consecutive number assigned to the student.
   - `W_school`: Indicates whether the student's school is managed by the government ($W_{school} = 1$) or if it is privately managed ($W_{school} = 0$)

You have authority to apply the exam to any 6th grader in Novarnia, and you can implement the program (tablet usage and monitor time) in all government-managed schools, but to include any students attending a private school to the program you must first obtain authorization from their school board.

Exercises

Consider $T_i \in \{0, 1\}$ the treatment status of student $i = 1, 2, ..., 1000$ — $T_i = 1$ if treated $T_i = 0$ if not treated. Potential outcomes $y_i(T_i)$ in `students`, measured in test results (grades 0 to 100) are defined:

- `y0`: vector $Y(0)$, assume we can't observe it unless specified.
- `y1`: vector $Y(1)$, assume we can't observe it unless specified.

1.1 What is the value of $y_3(1)$? Describe its meaning —in terms of the potential outcomes framework.
1.2 What is the value of $y_5(0)$? Describe its meaning.
1.3 Compute $\bar{Y}(1)$. Describe its meaning.
1.4 Suppose $T = 0$. What is the value of y_{20}^{obs} and y_{40}^{miss} ? Briefly explain why.
1.5 Suppose $T_i = 1$ for all $i = 1, 2, 3, ..., 1000$. What is $\bar{Y}^{obs}$?
1.6 Imagine you can observe both potential outcomes.
  (a) What is the causal effect of Project Mentor in student 245?
  (b) What is the estimated Average Treatment Effect (ATE) of Project Mentor?
  (c) Does the estimated ATE support the Prime Minister's claims?

In practice, only Y^{obs} will be available after applying the exam. You will observe **one test score per student**, as well as the students' treatment status: either treated or untreated.

After careful consideration, your team assigned N_0 students to control and N_1 students to treatment out of the $N_0 + N_1 \equiv N = 1000$ sampled. The assignment criteria included logistics, the school-year timeline, operation costs and potential political opposition. Treatment was allocated amongsts students per the rule

$$T = W_{school}$$

2.1 Explain the assignment rule in simple words
2.2 For each of the assignment criteria, provide a brief circumstance that likely motivated Novaria's government to conclude this was the best allocation.
2.3 What is the value of N_0?
2.4 What is the value of N_1?
2.5 Create a variable for $Y^{obs}(W)$, and name it `yobs_w`. With this variable:
  (a) Compute the value of $\bar{Y}^{obs}(1)$.
  (b) Compute the value of $\bar{Y}^{obs}(0)$.
2.6 Write down both expressions $\bar{Y}^{obs}(\cdot)$ more formally, in terms of summations.
2.7 Your team knows that $ATE = E(y_i^{obs}|W = 1) - E(y_i^{obs}|W = 0)$ but they don't know why, or how to estimate it from our sample.
  (a) What is $\widehat{ATE}$?
  (b) Justify your answer in terms of a famous mathematical theorem:
    i. $\square \xrightarrow{\square} E(y_i|W = 1)$
    ii. ...
    iii. Therefore the estimate ...
  (c) Compute $\widehat{ATE}$ using R.
  (d) **Reflect on the result**. How does it compare to your answers in 1.6b and 1.6c? At this point, do we have any way to diagnose the accuracy of this result?
2.8 Again, let's imagine we can observe potential outcomes. In the lecture, it was shown that the ATE can be decomposed in *treatment on the treated* and *selection bias*. Write down that expression and estimate the values of:
  (a) treatment of the treated
  (b) selection bias

(c) each individual term in *selection bias*

2.9 What do these values imply for the experiment's design? Is the value for 2.8a a potentially good $\widehat{ATE}$? What would be omitted if we were to only consider this value?

Case study O.7.2

Evaluating AI-assisted learning on student outcomes (continued)

Instructions: Work in pairs or groups of 3; answer the questions as concisely as possible. Type your answers in a single shared document or in the format required by the instructor.

One of you must set up a blank Colab notebook to work on, and share it with the rest. Save any figures or output, and incorporate as required by the instructor.

This is a direct continuation of G.7.4, thus we will work under the context you already have. Continue to use `students` when necessary to answer the questions.

Scenario: You let the Prime Minister know the treatment allocation for the Project Mentor experiment you had previously agreed on is problematic. He hires a team of consultants to help you sort this design problem out, as well as polish other details of the experiment. The following exercises are contain some of the questions asked during the meetings held with the consulting team and the Prime Minister.

Meeting 1

1.1 Firstly, you are asked to explain generally why you cannot get a credible average treatment effect from the current treatment allocation. How would outcomes be different we were to scale up the program nationally? (use your "secret" knowledge of the potential outcomes)

1.2 You are asked to provide an alternative assignment that would create two groups equally representative of 6th-graders nationally. Create such assignment variable under the name `T`, and also create `yobs_t`, the outcome we would observe under this assignment. Calculate the $\widehat{ATE}$. How does this result compare to 2.8a in G.7.4? Without making any further calculations, what do you think the treatment effect among private schoolers will be?

1.3 The Prime Minister doesn't believe that your new assignment created comparable groups. One way to provide evidence of balance, is showing the groups have the same composition of public and private schoolers. Formally show there is no evidence to reject the composition is the same. Be as conservative as possible with the variance.

1.4 Imagine everyone can observe potential outcomes. From the definition of ATE, show treatment and control are comparable more decisively.

Meeting 2

While more convinced of your new assignment, the Pime Minister still insists asking for permission to private schools is impractical and will delay matters. Conveniently, the consulting team asks two questions:

- Whether attending a private/public school in Novartia actually creates systematic differences between students; particularly, differences related to the outcome. This has not been formally shown.
- Whether there may be differences in treatment effects between public and private students (e.g. the mean effect is larger for any), as these differences would justify different rollouts.

To provide evidence in favor or against these questions, bear in mind we have to start from the following assumption:

$$y_i(0)|W = 0 \sim Distr(\mu_0,\ \sigma^2_{0,0})$$
$$y_i(1)|W = 0 \sim Distr(\mu_1,\ \sigma^2_{1,0})$$
$$y_i(0)|W = 1 \sim Distr(\nu_0,\ \sigma^2_{0,1})$$
$$y_i(1)|W = 1 \sim Distr(\nu_1,\ \sigma^2_{1,1})$$

Where $\sigma^2_{0,0} \neq \sigma^2_{0,1} \neq \sigma^2_{1,0} \neq \sigma^2_{1,1}$

2.1 In your own words what do these assumptions mean? What do they entail when it comes to testing hypotheses? According to the lecture, what should we assume about the correlation among these random variables if we want to be conservative?

2.2 Answer the question about systematic differences in outcomes between public and private schools with the evidence you have.
   (a) State the appropriate null hypotheses and their alternates.
   (b) Test them with the appropriate statistic (estimate any parameters you don't know).
   (c) Tie your conclusions directly to the question with 95% confidence.

2.3 Answer the question about differences in treatment effects.
   (a) State the appropriate null hypotheses (test equality).
   (b) Make inference on $\hat{\nu}_1, \hat{\nu}_0, \hat{\mu}_1, \hat{\mu}_0$ accordingly.
   (c) Tie your conclusions directly to the question with 95% confidence.

Meeting 3

Satisfied with your answers, the Prime Minister and consultants approach you with some final questions about the program's broader implications:

3.1 **SUTVA violations** In your own words, briefly explain the Stable Unit Treatment Value Assumption (SUTVA). Could implementing Project Mentor violate this assumption in Novaria? Provide a specific scenario illustrating such a violation clearly. How might these externalities affect the accuracy of your estimates?

3.2 **Alternative policies with proven outcomes (e.g. TaRL)** The consultants suggest evaluating cheaper alternatives, like Teaching at the Right Level — targeting teaching to each student's current skill level without advanced technology; human mentors, complementary material, smaller traditional groups (more teachers), among others. These alternatives currently have more robust evidence of their effects.

   (a) What, if any, are some differences between the theory of change underlying TaRL and that of Project Mentor?

   (b) If differences exist, briefly discuss how you would test them within an experimental design, clearly describing treatments, assignment and measured outcome(s).

   (c) Apart from the treatment effects, what else is necessary if we wanted to fairly compare any known TaRL intervention to Project Mentor in terms of efficiency?

   (d) In this comparison, how important do you think scale would be? Briefly describe how costs for one and the other would behave.

3.3 **Non-compliance** Not every school or student may strictly follow the treatment assignment. Describe one realistic scenario of non-compliance in this project. Explain briefly how such non-compliance might bias the estimated treatment effect. Suggest one practical strategy to reduce or mitigate non-compliance.

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Week 8 Instructions

Some title

Checklist

- ☐ Watch the linear models with R: `lm` tutorial[5] (Requirement)
- ☐ Complete Guided Case Study 5 (Session 1)
  - ☐ Get the `bike_rentals` dataset here
- ☐ Complete Guided Case Study 6 (Session 2)
  - ☐ Get the `student_performance` dataset here
- ☐ Complete Guided Case Study 7 (Session 2)
  - ☐ Get the `kc_house_data` dataset here
- ☐ (Optional) Explore **Review Notes** and further **Readings** available.

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[5] **Module 8 > Introduction to the Class lm** in the online component of the course.

Guided case study G.8.5

Part A - Bike rentals

Instructions: Work in pairs or groups of three. Solve the exercises for Part A of *Linear Regression* in Colab. Work collaboratively in a single Notebook.

Notebook: Part A

Dataset: bike_rentals.csv

Type your answers in the notebook, and submit your work per the instructor's requirements.

Guided case study G.8.6

Part B - Student performance

Instructions: Work in pairs or groups of three. Solve the exercises for Part B of *Linear Regression* in Colab. Work collaboratively in a single Notebook.

Notebook: Part B

Dataset: student_performance.csv

Type your answers in the notebook, and submit your work per the instructor's requirements.

Guided case study G.8.7

Part C - KC Housing Data

Instructions: Work in pairs or groups of three. Solve the exercises for Part C of *Linear Regression* in Colab. Work collaboratively in a single Notebook.

Notebook: Part C

Dataset: kc_house_data.csv

Type your answers in the notebook, and submit your work per the instructor's requirements.

Additional resources

- Drive: Review Notes
- Drive: Readings